Dihadron correlation in Au+Au collision at 200 GeV: jet quenching and medium response

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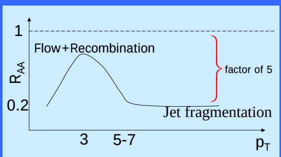
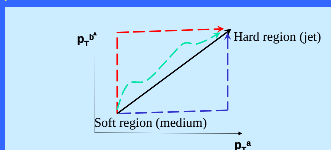
Jiangyong Jia
Chemistry Department, Stony Brook University

Importance of p_T scan

- High p_T: Jet dominated
  - Jet quenching and jet tomography
  - Constrain eloss dynamics (together with single hadron production)
- Low p_T: Bulk dominated
  - Response of medium to the lost energy
  - Probe the bulk dynamics (such as collectivity and hadronization)
  - Dihadron picks up jet signal, so can quantify jet contribution at low p_T (hard and soft separation).
- p_T scan: Evolution of jet fragmentation and medium response
  - Need to map out the full $p_T^a \times p_T^b \times \Delta\phi$ landscape





Many different ways of mapping out the transition

Some technical details

- Tools: Per-trigger yield (PTY), hadron-pair yield (JPY)
  - PTY = JPY/ N_{trig}.
  - Both the expected JPY and number of triggers (N_{trig}) scale with Ncoll.
- Quantify the medium modification
  - R_{AA}= singleyield$_{AA}$/(singleyield$_{pp}$ Ncoll) –modification of single particle yeild
  - J_{AA} = JPY$_{AA}$/(JPY$_{pp}$ Ncoll) –modification of jet-induced two particle yield
  - I_{AA} = PTY$_{AA}$/PTY$_{pp}$– modification of conditional (per-trigger) yield

Thus PTY, JPY, single yield and their modification factors are related:

$$JPY(p_T^a,p_T^b) = PTY(p_T^a,p_T^b)\frac{dN^a}{N_{evt}dp_T^a} = PTY(p_T^b,p_T^a)\frac{dN^b}{N_{evt}dp_T^b}$$

$$J_{AA}(p_T^a,p_T^b) = I_{AA}(p_T^a,p_T^b)R_{AA}(p_T^a) = I_{AA}(p_T^b,p_T^a)R_{AA}(p_T^b)$$

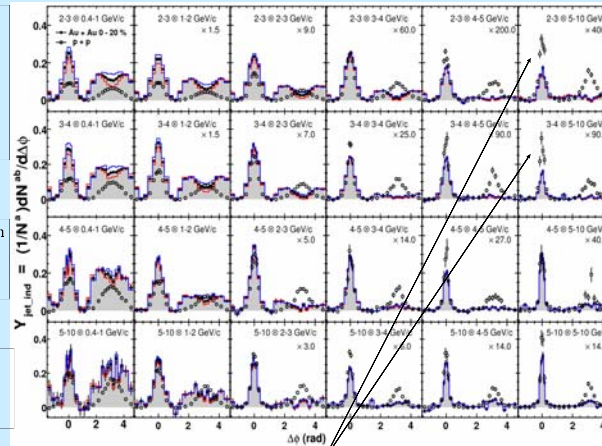
Correlation Landscape in $p_T^a \times p_T^b \times \Delta\phi$

Relative to pp, away-side Au+Au data show substantial modification with p_T^a and p_T^b.

- Soft region: broad and flat distribution
- Hard region: peaked like p+p
- In between: peaks at $\Delta\phi=\pi\pm1.1$ with local minimum at π.

Suggests a two component interpretation
- A suppressed jet component around π
- An enhanced medium component around $\pi\pm1.1$.

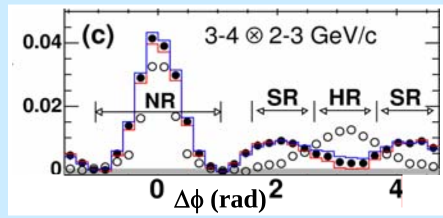
Significant modifications on the near side as well. Which can also be interpreted as sum of jet and medium component (ridge)



Near side suppression due to dilution effects of soft triggers

The evolution pattern suggests three distinct $\Delta\phi$ regions:

- NearRegion ($|\Delta\phi|<\pi/3$)
  - Jet+ ridge
- HeadRegion ($|\Delta\phi-\pi|<\pi/6$)
  - Jet suppression
- ShoulderRegion ($\pi/6<|\Delta\phi-\pi|<\pi/3$)
  - Response of the medium



We quantify the near-side shape and yield in these three $\Delta\phi$ regions

Jet Shapes

Two fitting method is used to determine location of shoulder

$$Y^{FIT1}_{jet\_ind} = G_1(\Delta\phi)+G_2(\Delta\phi-\pi+D)+G_2(\Delta\phi-\pi-D)+\kappa$$

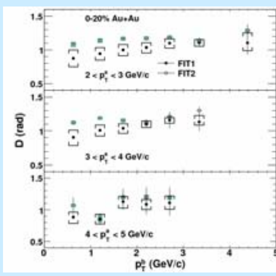
Assuming only medium response (shoulder component) for the away-side

$$Y^{FIT1}_{jet\_ind} = G_1(\Delta\phi)+G_2(\Delta\phi-\pi+D)+G_2(\Delta\phi-\pi-D)+G_3(\Delta\phi-\pi)+\kappa$$

Assuming both jet and medium component for the away-side

G1 — nearside jet, G2 — shoulder component, G3 — head component

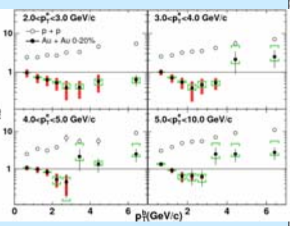
The shoulder is located around 1-1.2 rad, may depends slightly on the p_T.

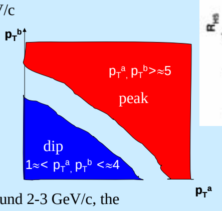


Compare the relative significant of the Shoulder and Head with R_{HS}: $R_{HS} = \frac{\int_{\Delta\phi\in HR} d\Delta\phi\, Y_{jet\_ind}(\Delta\phi)}{\int_{\Delta\phi\in HR} d\Delta\phi} \Big/ \frac{\int_{\Delta\phi\in SR} d\Delta\phi\, Y_{jet\_ind}(\Delta\phi)}{\int_{\Delta\phi\in SR} d\Delta\phi}$

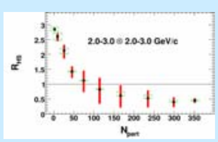
The full p_T^a, p_T^b dependence of R_{HS}.
Each $\Delta\phi$ distribution produce one R_{HS} number

- R_{HS}~1 for $p_T^{a,or\ b}$ <1 GeV/c
- R_{HS}<1 for 1<$p_T^{a,b}$<4 GeV/c
- R_{HS}>1 for $p_T^{a,b}$>5 GeV/c





R_{HS} reach minimum around 2-3 GeV/c, the centrality dependence in this p_T bin shows
A fast drop at Npart<80, but slowly saturates at around 0.5 at Npart>200

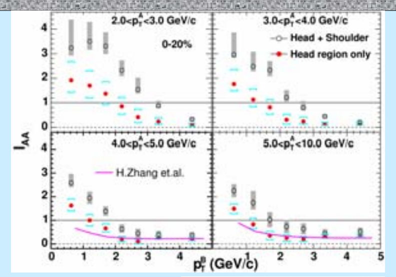


Jet Per-trigger Yields

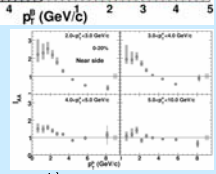
Quantify the modification relative to pp via I_{AA}

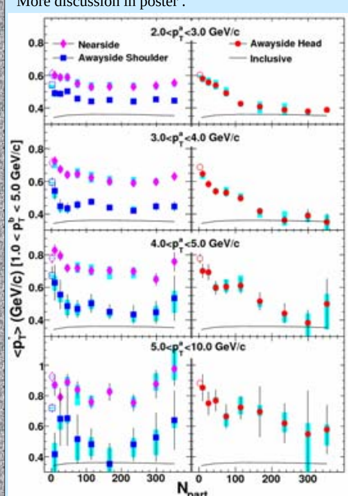
$$I_{AA}(p_T^a,p_T^b) = \frac{Y^{A+A}_{jet\_ind}(p_T^a,p_T^b)}{Y^{p+p}_{jet\_ind}(p_T^a,p_T^b)}$$

- SR exhibit early onset of suppression—jet quenching
- H+S (entire away-side) relative to SR exhibit overall enhancement — enhancement due to medium response
- High p_T trigger results are consistent with jet quenching calculation.
- HR contains significant feedin from SR.



Note soft trigger (2-3 and 3-4 GeV/c) have apparent stronger suppression than hard triggers(4-5 and 5-10GeV/c) at large p_T^b. This is due to a dilution effects of soft triggers, which is enhanced by soft processes at intermediate p_T (2-4 GeV/c). This is also indicated by a suppression of near-side I_{AA} and can be seen directly from the near-side $\Delta\phi$ distribution. More discussion in poster .





- Near-side: flat with Npart (>100), increase with p_T^a.
  —Jet fragmentation
- Shoulder region: flat with Npart (>100) , independent of p_T^a
  —Universal slope, reflects property of the medium?
- Head region: drops with Npart – suppression
  increases with p_T^a –punch-through jets

Away-side modification are sensitive to p_T and $\Delta\phi$ range. Thus a flat Npart dependence does not necessarily mean jet is not modified. A full p_T and $\Delta\phi$ survey is important!!

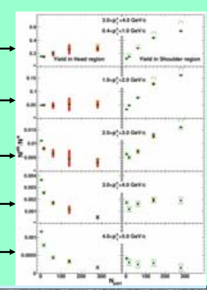
Both HR and SR increase with Npart

HR flat with Npart and SR increase with Npart

HR decrease with Npart and SR increase with Npart

HR decrease with Npart and SR flat with Npart

HR decrease with Npart and SR decrease with Npart



Jet Hadron-Pair Yields

Pair yield (JPY) scales with Ncoll. Its modification is quantified by J_{AA}

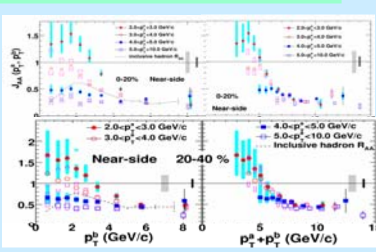
$$J_{AA}(p_T^a,p_T^b,\Delta\phi) = \frac{JPY^{A+A}}{\langle N_{coll}\rangle\, JPY^{p+p}} = \frac{1}{\sigma_{A+A}}\frac{d^3\sigma^{A+A}_{jet\_ind}}{dp_T^a dp_T^b d\Delta\phi} \Big/ \frac{\langle N_{coll}\rangle}{\sigma_{p+p}}\frac{d^3\sigma^{p+p}_{jet\_ind}}{dp_T^a dp_T^b d\Delta\phi}$$

J_{AA}, I_{AA} and R_{AA} are related:

$$J_{AA}(p_T^a,p_T^b) = I_{AA}(p_T^a,p_T^b)R_{AA}(p_T^a) = I_{AA}(p_T^b,p_T^a)R_{AA}(p_T^b)$$

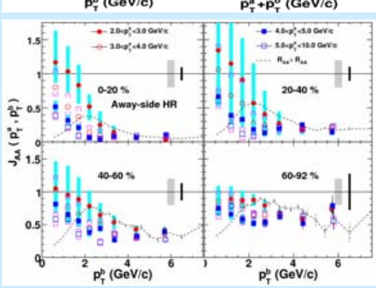
High p_T correlation: Per-trigger yield effectively represent per-jet yield, PTY and I_{AA} is more robust
Low p_T correlation: jet fragmentation is not the only sources of triggers, JPY and J_{AA} is more robust

- Near-side J_{AA} scales with p_T^{sum}= p_T^a + p_T^b
  - Nearside pairs come from same jet, p_T^{sum} is a good proxy for original jet energy
- J_{AA} ~ R_{AA} at large p_T^{sum}
  - Suppression of J_{AA} represent the suppression of jet-induced contribution from same jets.



Away-side J_{AA} ~ R_{AA}^2 (within large errors) at large p_T^{sum}.

Suggests that the suppression of away-side jets (I_{AA}) is similar to that for inclusive jets (R_{AA})



Summary

1)The evolution of the jet shape and yield with pt seems to suggest four distinct contributions to jet-induced pairs: 1) a jet fragmentation component around $\Delta\phi$~0 , 2) a punch-through jet fragmentation component around $\Delta\phi$~π, 3) a medium-induced component around $\Delta\phi$~0, and 4) a medium-induced components around $\Delta\phi$~$\pi\pm1.1$.
2) The fact that both near- and away-side distributions are enhanced and broadened at low pt and that the modifications limited to p_T<4 GeV/c, above which the jet characteristics qualitatively approach jet fragmentation, may suggest that the modifications mechanisms for the near- and away-side are related.

Model comparisons

1) If jets are generated close to the surface, they exit and subsequently fragment outside the medium (surface emission or punch-through as in Renk:2006pk,Zhang:2007ja). Otherwise they lose energy by radiating gluons.These shower gluons may be emitted at large angles relative to the original partons (Vitev:2005yg,Polosa:2006hb} and fragment into hadrons, or they can be deflected to large angles by interactions with medium, including medium deflection in the azimuthal{Chiu:2006pu,Armesto:2004pt} and the beam directions {Majumder:2006wi} or excitation of collective Mach shock{Stoecker:2004qu, Casalderrey-Solana:2004qm}.
2) However, many of these models are either qualitative in nature or they focus on subset of the dijet observables (jet shape or yield, near- or away-side, high p_T or low p_T). A model framework including both jet quenching and medium response, which can describe the full p_T evolution of the jet shapeand yield at both near- and away-side is required to understand the parton-medium interactions. Our data provide valuable guidance for such future model developments.